SORENSEN
POWER SUPPLIES

Instruction Manual

QSA SERIES

NARROW RANGE POWER SUPPLIES

THIS MANUAL COVERS THE FOLLOWING QSA MODELS

18-1.1	75-.5
18-1.9	75-.8
18-3.0	120-.5
48-.4	175-.25
48-.8	265-.15
48-1.2	

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RAYTHEON

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1. INTRODUCTION

1-1. INTRODUCTION

1-2. This manual contains operating and maintenance instructions on the comprehensive, narrow-range QSA power supply line, manufactured by Sorensen Company, 676 Island Pond Road, Manchester, N. H. The line consists of 11 models, all similar in electrical design and physical appearance, and differing only in output voltage and current ratings.

1-3. This manual is made up of six sections. This introduction and a general description of the unit and its applications, along with complete unit specifications and performance curves, form Section I. Section II details procedures to be followed when a unit arrives at destination. It also contains procedures for adapting a unit for alternate input voltages. Operating procedures and instructions for modifying the unit for a number of applications are outlined in Section III. Section IV discusses principles of operation. Troubleshooting, calibration, and performance-testing procedures are furnished in Section V. The last section contains a unit parts list.

1-4. DESCRIPTION.

1-5. Designed for operation on any of three separate, single-phase inputs, the units provide a variety of highly regulated d-c outputs. (Refer to Table 1-1 for unit specifications.) They also offer extremely fast recovery times as well as characteristically low output impedances.

1-6. Good selectivity in mounting position is a unique feature. The units may be end, bottom or side mounted, using the enclosures as mounting surfaces. These enclosures, finished with a blue, baked-on, mar-resistant wrinkle coating, serve both to protect the units in the event of mishandling and as a heatsink. This latter feature eliminates the need for an external heat-dissipation device.

1-7. Operational features include remote sensing, remote programming, and series and parallel operation. Overload and short-circuit protection is provided by a current-foldback system.

1-8. REMOTE SENSING. In applications where variations in the load-lead drops adversely affect load regulation, remote sensing may be used to extend the unit's regulating point from the output terminals to the load. In the QSA series, remote sensing will compensate for 1.5V of drop per load lead, maximum.

1-9. REMOTE PROGRAMMING. With the remote-programming feature, unit output voltage may be altered from a remote location by introducing a calculated resistance, or voltage signal, into the programming network. For resistance programming, the ohms/volt ratio is approximately 40. Signal programing sensitivity is a volt/volt.

1-10. SERIES OPERATION. Two QSA models may be series connected to provide a system output voltage greater than either of the units connected singly can supply.

1-11. PARALLEL OPERATION. For applications requiring current higher than one unit can provide, QSA units may be connected in parallel. For a discussion on the number of units which may be paralleled, refer to para. 3-25.

1-12. OVERCURRENT PROTECTION. In the event of an overcurrent condition, e.g., short circuit, a current-foldback circuit (preset at the factory to 125% of rated current at 50°C), operates to reduce both the unit output voltage and current.

1-13. OPTIONAL ACCESSORIES.

Rack adapters are offered as optional accessories to the QSA line, all designed for standard 19 inch (483 mm) racks. There are six basic rack assemblies to mount various combinations of different power supplies. The rack assemblies include provisions for slide rails and offer added versatility in that units may be mounted both at the front and rear of the adapter. Racks are supplied in 3½ and 5¼ inch (89 and 133 mm) heights and three depths; 3.62 inches (92 mm), 18 inches (457 mm), and 20 inches (508 mm).

There are four filler panels available:

Metered

PM300 3½" (89 mm) height
PM500 5¼" (133 mm) height

Unmetered

PF300 3½" (89 mm) height
PF500 5¼" (133 mm) height

The metered panels (which can accommodate five meters), include a voltmeter, voltage selection knob, three meter lenses and three meter filler blocks. Consult your factory representative for complete system design.

Table 1-1 Unit Specifications

	ALL MODELS	18-1.1	18-1.9	18-3.0	48-.4	48-.8
INPUT RATINGS						
Voltage (Vac)	105-125/200-240/ 210-250					
Frequency (Hz) (1)		50-480	50-480	50-480	48-480	48-480
Phase	Single					
Max. Current (Aac)						
at 115 Vac		0.8	1.3	1.8	0.7	1.3
at 230 Vac		0.4	0.65	0.9	0.35	0.65
Recommended Fuse Sizes Bussman Type 3AG or equiv.						
115 Vac (A)		1.0	1.5	2.5	1.0	1.5
220/230 Vac (A)		0.5	0.75	1.25	0.5	0.75
Power Factor (typ)		0.83	0.83	0.82	0.83	0.79
Efficiency (typ) (%)		31	33	38	38	44
OUTPUT RATINGS						
Voltage (Vdc)		14-22	14-22	14-22	35-60	35-60
Resolution (mV) (typ)		45	45	45	135	135
Current (Adc) (50°C) (2)		0-1.1	0-1.9	0-3.0	0-0.4	0-0.8
Current Foldback Regulation (%)	See Figure 1-2	±0.005	±0.005	±0.005	±0.005	±0.005
Ripple Voltage (max)						
RMS (μV) 50-60 Hz		300	300	300		
48-60 Hz					300	300
Peak-to-Peak (mV)						
50-60 Hz		3	3	3		
48-60 Hz					3	3
Temperature Coefficient Voltage (% Eo/°C)		0.01	0.01	0.01	0.015	0.015
Output Voltage Turn-On, Turn-Off Overshoots	None					
Transient Response (NL to FL and FL to NL step changes)						
Recovery to within ±10 mV band (μsec)		20	20	20		
Recovery to within ±15 mV band (μsec)					20	20
Recovery to within ±20 mV band (μsec)						
Ambient Temperature Range	0-71°C See Figure 1-1					
Remote Programming		40 ohms/volt (approx)				
Output Impedance	R + jwL					
R (mΩ)		0.75	0.04	0.3	2.4	2.4
L (μh)		0.4	0.4	0.3	0.8	0.8
Stability (8 hrs after warmup with constant load, line, amb temp)	0.025% Eo/8 hrs (typ)					
Series Operation Parallel Operation	2 units Refer to Para 3-25					
Remote Sensing			1.5 V/leg drop max.			

	48-1.2	75-.5	75-.8	120-.5	175-.25	265-.15
	48-480	48-480	48-480	48-480	48-480	48-480
	1.8 0.4	1.2 0.6	1.7 0.85	1.8 0.9	1.2 0.6	1.3 0.65
	2.5 1.25	1.5 0.75	2.5 1.25	2.5 1.25	1.5 0.75	1.5 0.75
	0.79 45	0.78 51	0.79 53	0.79 50	.75 54	.72 48
	35-60 135	60-90 115	60-90 115	90-150 145	150-200 160	200-330 160
	0-1.2 ±0.005	0-0.5 ±0.005	0-0.8 ±0.005	0-0.5 ±0.01	0.18 ±.01	0.15 ±.01
	300 3	300 3	300 3	300 3	300 3	300 3
	0.015	0.015	0.015	0.015	0.015	0.015
	20	20	20	20	20	20
					90 ohms/volt	
	2.4 0.4	3.8 0.8	3.8 0.4	6.0 0.8	40 1.6	70 1.6
		0.5V				

Table 1-1 Unit Specfications (Cont'd)

	ALL MODELS	18-1.1	18-1.9	18-3.0	48-.4	48-.8
Cooling	Natural Convection					
RFI Characteristics (typ)		Meets or Surpasses Requirements of Specifications Mil-I-16910				
Dimensions: in inches (mm) Width		3-7/8 / 98	5-1/8 / 130	5-1/8 / 130	3-7/8 / 98	5-1/8 / 130
Height	3-5/16 / 84					
Depth		7 / 178	7 / 178	10 / 254	7 / 178	7 / 178
Weight In Lbs. (Kg.)		5 / 2.27	8 / 3.63	10 / 4.54	5 / 2.27	8 / 3.63

(1) Unit will operate over frequency range indicated. However, these specifications are for a 60 Hz input only.
(2) For higher ambients, derate output per Figure 1-1.

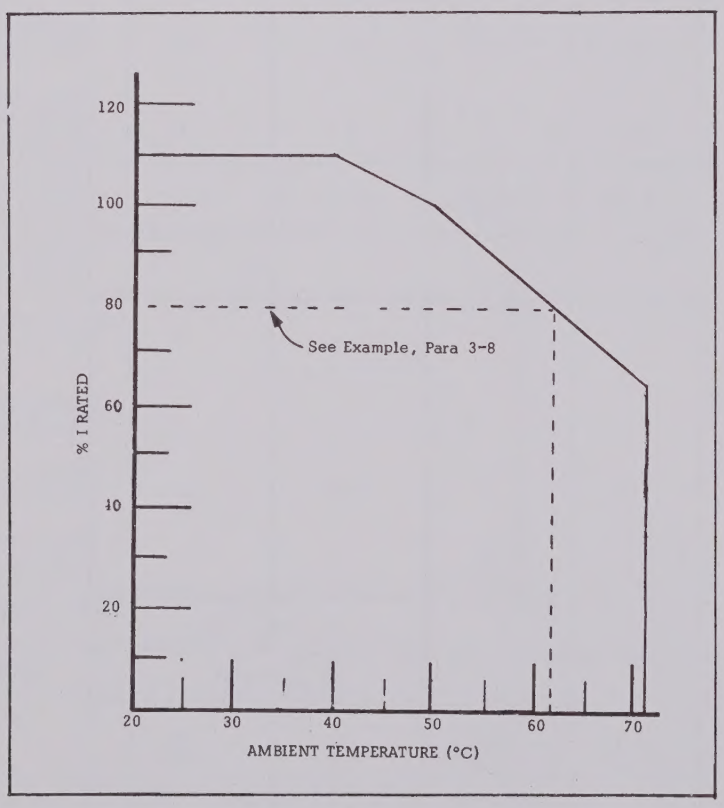


Figure 1-1. Current Derating Characteristics

	48-1.2	75-.5	75-.8	120-.5	175-.25	265-.15
	and Mil-I-1681					
	5-1/8 130	5-1/8 130	5-1/8 130	5-1/8 130	5-1/8 130	5-1/8 130
	10 254	7 178	10 254	10 254	10 254	10 254
	10 4.54	7 3.63	10 4.54	10 4.54	10 4.54	10 4.54

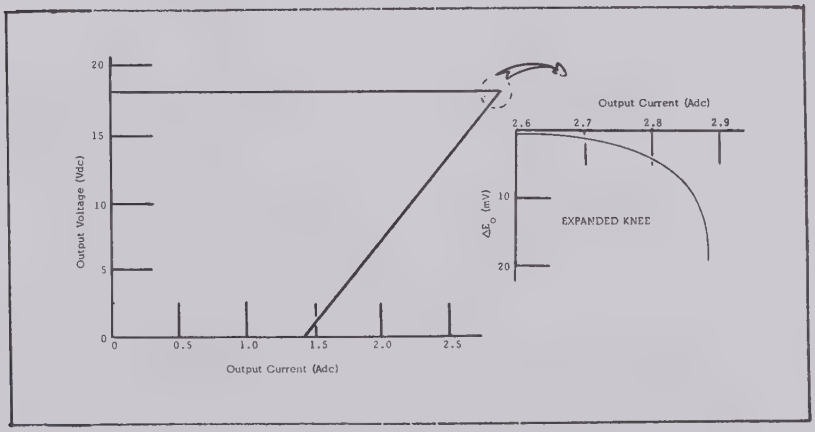


Figure 1-2. Current Foldback Characteristics (typical)
(QSA 18-1.9 shown)

2. INSTALLATION

2-1. INTRODUCTION.

2-2. Following unpacking, incoming inspection and preliminary checkout procedures should be performed to make certain that unit is in good working order. These consist basically of visually inspecting for physical damage and of making some electrical checks. It if is determined that the unit is damaged, notify the carrier immediately. The carrier's claim agent will then prepare a report of damage. The user is required to send this report to the Service Dept., Sorensen Company, 676 Island Pond Road, Manchester, N. H. 03103. Sorensen will advise the user as to what action is required to repair or replace the supply.

2-3. INSPECTION.

2-4. Check for damage incurred during shipment as follows:

a. Inspect enclosures for dents, chips, and other signs of obvious damage.

b. Check condition of external terminal board. Make certain that all terminal screws are in place and that links are fitted over the barrier strips between terminals 1 and 2, and between 3 and 4.

c. Using a screwdriver, rotate Output Adjust (adjustment aperture is located in nameplate) from stop-to-stop, and then turn fully counterclockwise. Rotation should be smooth through a 300-degree angle.

d. Remove four screws retaining side enclosure plate, and inspect component board.

e. Remainder of enclosure may be removed by removing mounting screws and hex-head cap screws at nameplate end. Inspect transformer, capacitors and passing-stage transistors.

NOTE

A guide pin, located at closed end of enclosure, should be used to align enclosure and chassis when reassembling unit. Tighten cap screws to 25 lb-in.

2-5. INPUT CONNECTIONS.

2-6. If either of the two alternatives to a nominal 115-Vac input is to be used, change transformer T1 primary tap wiring as indicated in Figure 2-1. The factory-wired 115-Vac configuration is included to facilitate reconversion to this input, if such action becomes desirable at some future date. Remount enclosures following inspection or tap changing.

NOTE

Fuse the input if it is desired to protect the power transformer and rectifiers from excessive currents caused by certain types of unit malfunction. Recommended fuse sizes are listed in Table 1-1, Unit Specifications, Sheet 1, under INPUT RATINGS.

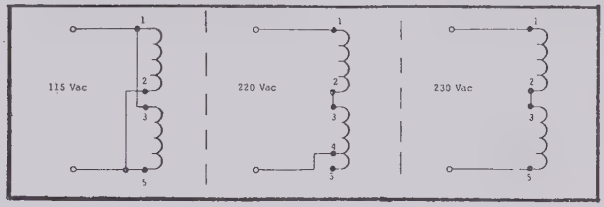


Figure 2-1 Input Connections

2-7. ELECTRICAL CHECK.

2-8. To perform an initial electrical check, proceed as follows:

a. Make certain unit is located in an area where free passage of air is unrestricted; then connect input leads to terminals 6 and 7 (IN) on unit terminal board. Use terminal 5 (GRD) for input system ground.

b. Connect a d-c voltmeter across terminals 1 and 4 (OUT). Select a voltage range compatible with rated output.

c. Apply nominal input power.

d. Rotate Output Adjust from stop-to-stop. Voltmeter pointer should swing from minimum to maximum rated output.

3. Set output voltage at its nominal value and remove input power.

2-9. MOUNTING.

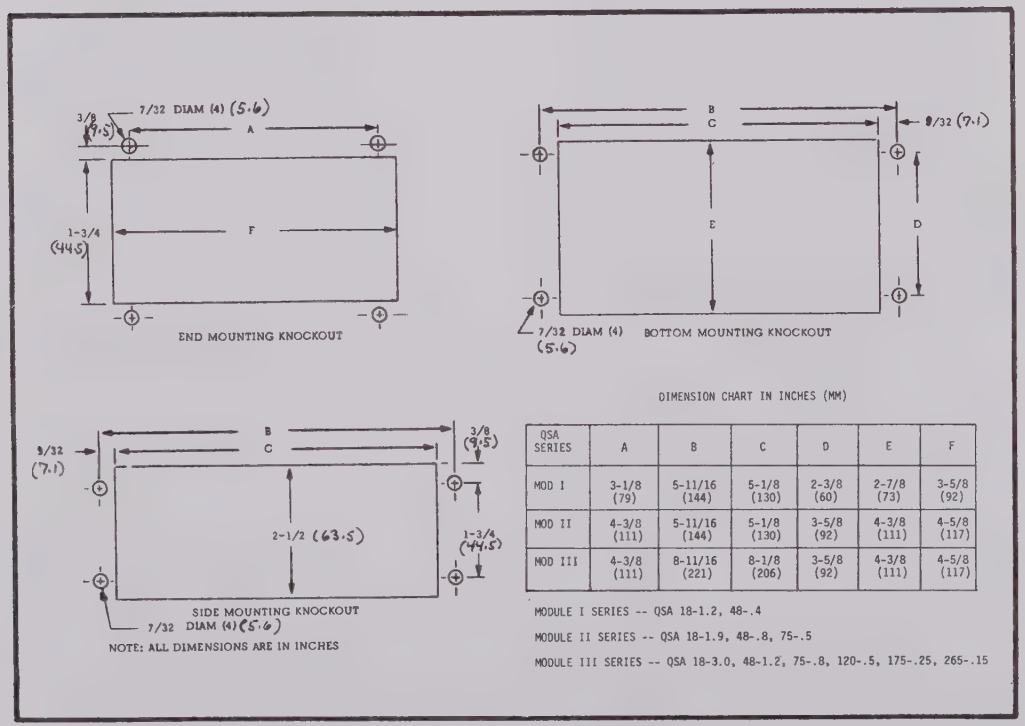
2-10. As previously mentioned, the units may be mounted in a variety of positions and locations, including a rack. Figure 2-2 illustrates the mounting-hole and knock-out dimensions for end, side and bottom mounting. Use No. 8-32 screws for mounting. In determining the length of screws to be used, consider washer and mounting-surface thickness and the 3/8 in. (9.5 mm) required for maximum thread engagement. When using nameplate-end mounting, place 1/4" (6.3 mm) spacers over mounting holes between unit and mounting surface.

CAUTION

Knockouts are required for proper dissipation of heat generated by supply. Do not reduce knockout dimensions, nor impede natural flow of air around supply.

NOTE

If it is expected that unit will be subjected to shock or vibration during operation, do not use nameplate-end mounting.



DIMENSION CHART IN INCHES (MM)

QSA SERIES	A	B	C	D	E	F
MOD I	3-1/8 (79)	5-11/16 (144)	5-1/8 (130)	2-3/8 (60)	2-7/8 (73)	3-5/8 (92)
MOD II	4-3/8 (111)	5-11/16 (144)	5-1/8 (130)	3-5/8 (92)	4-3/8 (111)	4-5/8 (117)
MOD III	4-3/8 (111)	8-11/16 (221)	8-1/8 (206)	3-5/8 (92)	4-3/8 (111)	4-5/8 (117)

MODULE I SERIES -- QSA 18-1.2, 48-.4

MODULE II SERIES -- QSA 18-1.9, 48-.8, 75-.5

MODULE III SERIES -- QSA 18-3.0, 48-1.2, 75-.8, 120-.5, 175-.25, 265-.15

Figure 2-2. Knockout Dimensions

If the units are to be rack mounted in the AC300 and AC500 optional adapter (figures 2-3 and 2-4), remove the adapter face plate, position the unit behind the adapter and then secure with hardware enclosed in the bag tied to the adapter handle. Fit the adapter to the rack and attach. Make the necessary input connections (paragraph 2.3), check electrically per paragraph 2.4, and adapt the unit to the desired application (section 3) before installing the face panel. If optional AC318, AC320, AC518 or AC520 rack adapters are to be used, (see Figure 2-5), your factory representative should be consulted.

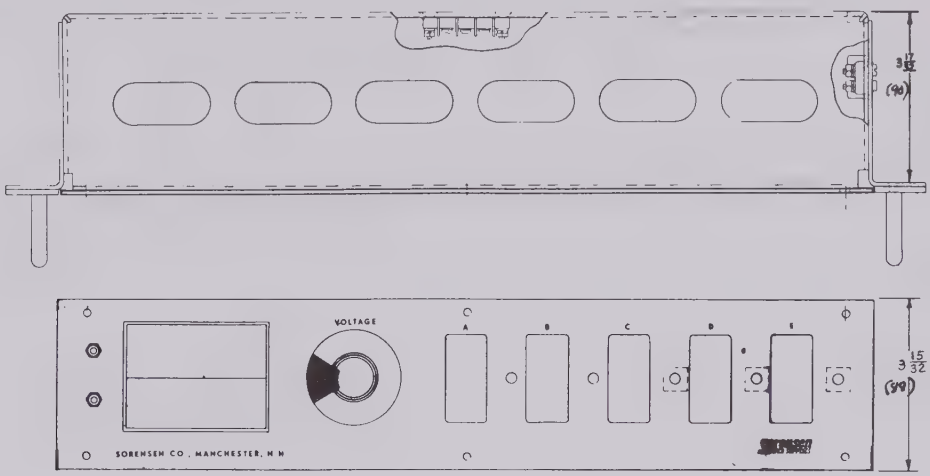


Figure 2-3 AC300 Rack Adapter (shown with metered panel)

NOTE

AC300 can accommodate three Module II or Module III units, or four Module I units.

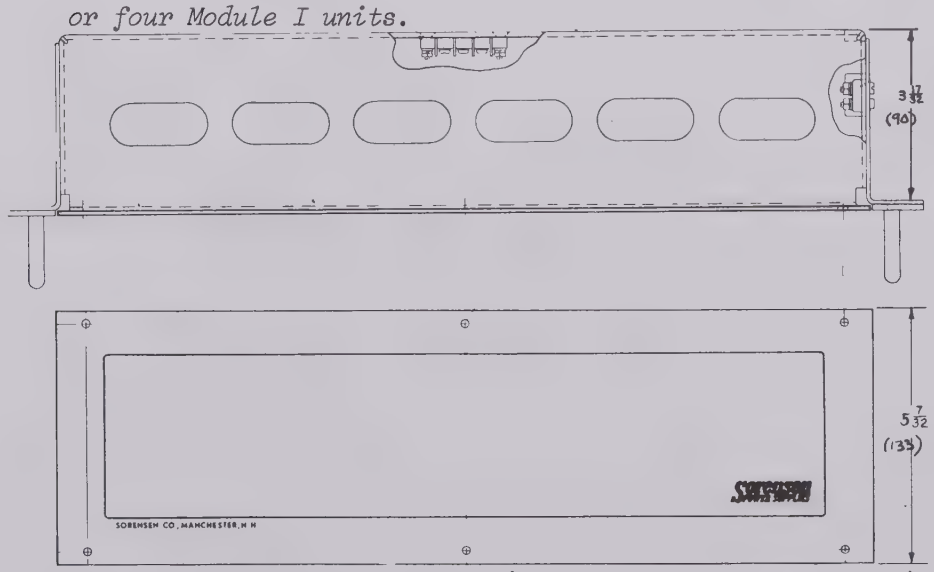
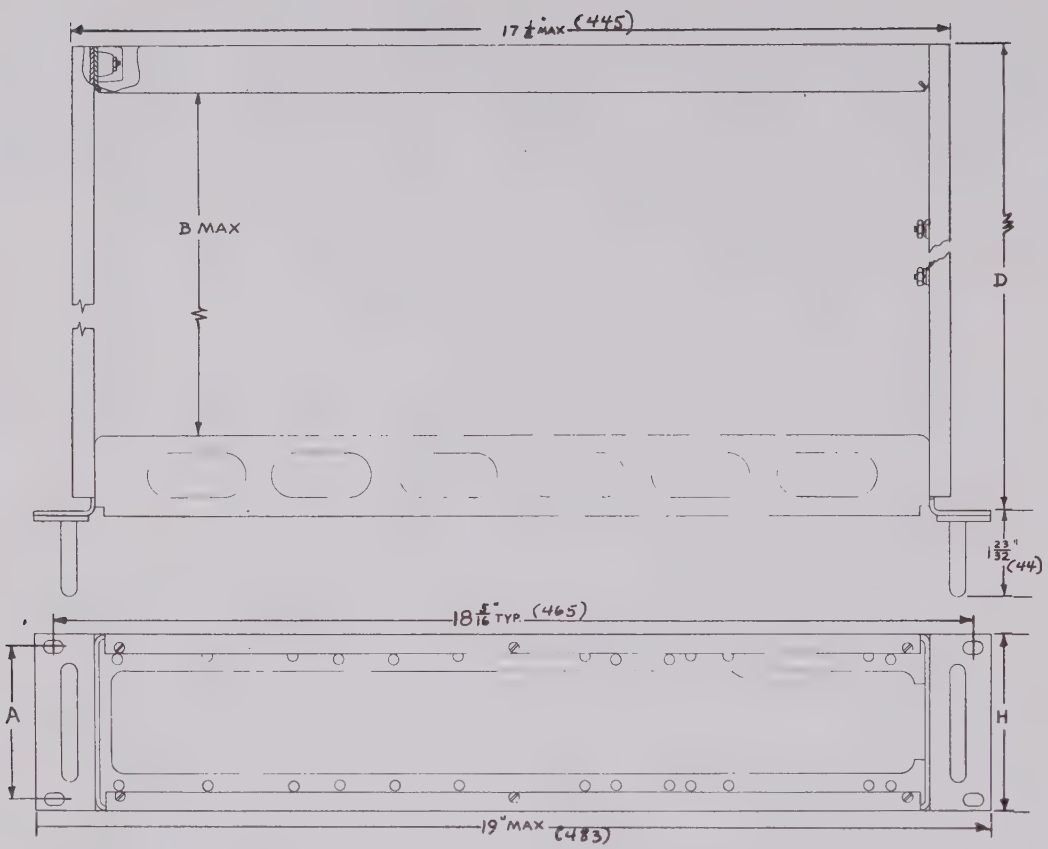


Figure 2-4 AC500 Rack Adapter (shown with unmetered panel)



MODEL	A	D	H
AC318	3 inches(76 mm)	17-1/2(445)	3-7/16(87)
AC320	3 inches(76 mm)	20 (508)	3-7/16(87)
AC518	2-1/4 inches(57 mm)	17-1/2(445)	5-3/16(132)
AC520	2-1/4 inches(57 mm)	20 (508)	5-3/16(132)

Figure 2-5 AC318, AC320, AC518, AC520 Rack Adapter

NOTE

These adapters will accommodate up to eight units.

3. OPERATION

3-1. GENERAL.

3-2. This section contains instructions on how to adapt the unit to, and operate it in, a number of varied applications. These include remote sensing, remote programming, and series and parallel operation.

CAUTION

The sensing and power circuits form a closed loop. Opening this loop, either by removing a terminal-board link or disconnecting a sensing or programming lead will result in a high unit output and may damage the load or the supply.

3-3. CONTROLS.

3-4. QSA units are equipped with a single operating control, the Output Adjust potentiometer. This control is accessible through an aperture located in the nameplate end. Connected in series with the sensing network and across the output terminals, it is used to vary the unit output voltage.

3-5. PREOPERATION CONSIDERATIONS.

3-6. CURRENT-FOLDBACK COMPENSATION. The current-foldback point is factory set to 125% of I rated at 50°C. If the unit is to be operated in ambients othern than 50°C, the rated output current follows the downward sloping line in Figure 1-1. The current foldback point, however, remains fixed. It is therefore recommended that for unit ambient temperatures other than 50°C, the foldback should be reset to 125% of the derated output current.

3-7. Compensation Calculation. The value to which the current foldback should be reset may be determined by the following equations:

For ambient temperatures between 50°C to 71°C:

$$I_{FB} = I_o \times 1.30^* \left[1-0.0167\ (T-50)\right]$$

For ambient temperatures between 40°C to 50°C:

$$I_{FB} = I_o \times 1.25 \left[1-.01\ (T-50)\right]$$

Where I_o is rated current at 50°C, T_o is ambient temperature in °C.

Note: 1.30 is based on setting being performed at room ambient. Otherwise, use 1.25.

3-8. Sample Calculation. For illustrative purposes, assume a model QSA 48-1.2 is to be operated in an ambient of 62°C. From paragraph 3.7:

$$I_{FB} = I_o \times 130 \left[1-0.0167\ (T-50)\right]$$

$$I_{FB} = 1.2 \times 1.30 \left[1-0.0167\ (62-50)\right]$$

$$I_{FB} = 1.3 \text{ amperes}$$

3-9. CURRENT-FOLDBACK RESET. To reset the current foldback, proceed as follows:

a. Remove side enclosure to expose component board.

b. Rotate foldback adjust potentiometer (R5) fully clockwise.

c. Connect a voltmeter across the output terminals. Apply nominal input power, and adjust output voltage to minimum value of unit's specified range, or if unit is to be used in an application requiring a fixed voltage within the range, set output to this value.

d. Remove input power, and series connect an ammeter and variable load across the output terminals.

e. Reapply input power, and adjust load so that test ammeter indicates current foldback current calculated in para. 3-7.

f. Rotate potentiometer R5 slowly counterclockwise until both output voltage and current begin to drop.

g. Remove input power, disconnect test instrument and load, and before remounting side enclosure, apply locking compound to R5.

3-10. LOCAL SENSING.

3-11. The unit is shipped ready for use in the local-sensing mode. In this mode, regulation is at the output terminals, not at the load. If variations in load-line voltage drops are expected to be prohibitive, refer to para. 3-13.

3-12. To operate the unit, proceed as follows:

a. Connect a voltmeter across output terminals 1 and 4.

b. Attach the input leads to terminals 6 and 7. Use terminal 5 (GRD) to ground input system.

c. Apply nominal input power.

d. Rotate Output Adjust until desired output voltage is indicated on voltmeter.

e. Remove input power, disconnect voltmeter and connect load leads to terminals 1 and 4. Do not remove or loosen any of the interconnecting links. Apply nominal input. Unit supplies highly regulated power to load.

WARNING

Do not touch enclosure while unit is operating under load. Surface temperature is comparatively high. If unit must be handled immediately after operation, wear heat-resistant gloves.

3-13. REMOTE SENSING.

3-14. If it is desirable to sense (regulate) unit output at the load rather than at output terminals, remove the links between terminals 1 and 2, and 3 and 4. Next, run a sensing lead from terminal 2 to the positive side of load; connect the other lead from terminal 3 to the negative side of load (see Figure 3-1). Sensing leads should be coaxial cable with the cable shield connected to the negative SENSE terminal. Put unit into operation per para. 3-12. With remote sensing unit transient response degenerates slightly. If this is an undesirable feature, the response characteristics may be maintained by disconnecting output capacitor C7 and connecting it, or an identical capacitor, locally across the load. Rating of C7 may be determined from parts list in Section VI.

NOTE

In remote-sensing operation, capacitive loading may result in an oscillating output (QSA 48-, 75- and 120-volt models only). If oscillations occur for this condition, stabilize output by connecting a 5 uf, 200 Vdc capacitor across unit output terminals.

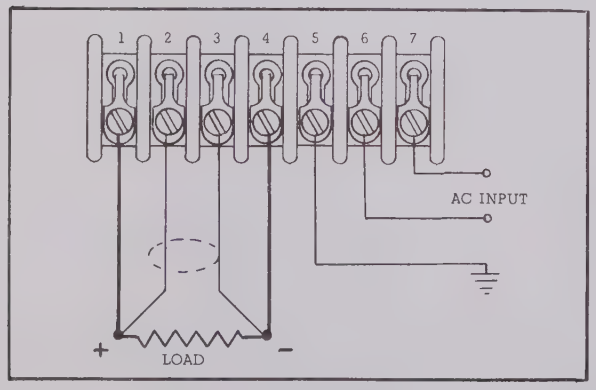


Figure 3-1. Remote Sensing Configuration

3-15. REMOTE PROGRAMMING.

3-16. RESISTANCE. The unit may be programmed to supply predetermined output voltages by inserting a calculated resistance into the voltage-sensing circuit. Programming sensitivity is approximately 40 ohms per volt, or in other words, 40 ohms are required for each volt difference between the desired output and the minimum value of the unit's specified range. Use a resistor with ±20 ppm/°C coefficient and a wattage rating at least ten times that calculated. Programming current is approximately 25mA.

3-17. To adapt the unit for remote programming, a precision variable resistor is placed across terminals 3 and 4 on the external terminal board (1 in Figure 3-2). Use shielded or twisted wire to connect the leads, (as an alternative, the jumper across studs E3 and E4 on the component board may be removed and replaced by the resistor, (2 in Figure 3-2). Access to the component board is achieved by removing the side panel. With resistor in place, proceed as follows:

a. Turn the OUTPUT ADJUST control fully counterclockwise.

b. Apply nominal input power and verify that the output voltage across terminals 1 and 4 is the desired value.

c. Disconnect the input power. Make the load connections and reapply input. Programmed output is now supplied to the load.

NOTE

To discontinue programming, remove the input and precision resistor. If jumper or link was removed reconnect it.

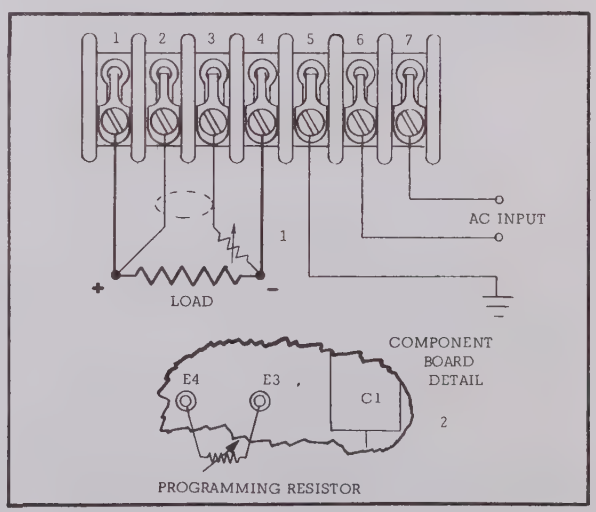


Figure 3-2. Resistance Programming Set-up

3-18. VOLTAGE SIGNAL. The procedure for adapting a QSA model for voltage-signal programming is identical to that for resistance programming, with this exception: instead of connecting programming resistor across terminals E3 and E4, connect the voltage-signal source. This source should be floating (ungrounded) and should be capable of producing a low-noise, low-ripple signal. The magnitude of the signal should not be greater than the maximum, nor less than the minimum, value of the unit's specified range (see Table 1-1). Voltage-programming sensitivity is a volt/volt.

3-19. SERIES OPERATION.

3-20. Series operation may be used to obtain a system output voltage greater than any single unit can provide. The specified number of units which may be placed in series is two. System regulation is the sum of the regulation for both units. The maximum current output is limited to the maximum current output of the lowest rated supply.

3-21. To series connect two units, proceed as follows:

a. At no load, apply nominal input power to both units, and adjust individual unit output voltages so that their sum is equal to the desired load voltage plus the calculated load-lead drops.

b. Remove input power.

c. Disconnect the links between terminals 1 and 2, and 3 and 4 on both units.

d. Connect load leads as shown in Figure 3-3; then hook-up sensing leads. Use coaxial cable for sensing leads, and connect cable shields to the negative SENSE terminals.

e. Connect rectifiers across individual unit output terminals. Refer to para. 3-22 for rectifier recommendations.

f. Apply nominal input. System supplies regulated voltage to the load.

3-22. RECTIFIER RECOMMENDATIONS. During series operation a system short circuit (or a unit malfunction) may damage a unit's output capacitor by causing a negative voltage to appear across the output terminals. To limit this voltage to about 1 volt, it is recommended that a rectifier be connected across each set of output terminals. Rectifiers recommended for use in series operation are listed in Table 3-1.

3-23. PARALLEL OPERATION.

3-24. Loads which draw currents higher than a single unit's rated output may be serviced by paralleling units. Parallel operation is based on the "master-slave" concept, i.e., drive current for "slave" units is supplied and controlled by the "master" unit.

3-25. The maximum number of units which may be paralleled is dependent upon the amount of drive current available from the "master" unit. This current, in turn, depends upon the variations, within allowable tolerances, in "master" unit component characteristics. The maximum number of units which may be paralleled then is a function of the "master" unit selected and varies from four, in the worst case, to fifteen.

3-26. The following outlines the procedures for paralleling two units. However, the procedure need only be extended to parallel up to the maximum number of units. Derate each unit to 90% of its maximum rated output current. Maximum system output is the sum of the derated currents.

a. Apply input power to "master" unit selected, adjust output voltage to desired system output and then disconnect input.

b. If remote sensing is desired, remove links between terminals 1 and 2, and 3 and 4 on "master" unit.

c. Connect load and sensing leads to load as depicted in Figure 3-4. Use coaxial cable for the sensing leads and connect shield to terminal 3 of "master" unit.

d. Remove side enclosures on both units, cut jumper across studs E1 and E2 of "slave" unit, and interconnect E1 of both units.

NOTE

Regulation degeneration is negligible in "master-slave" parallel operation.

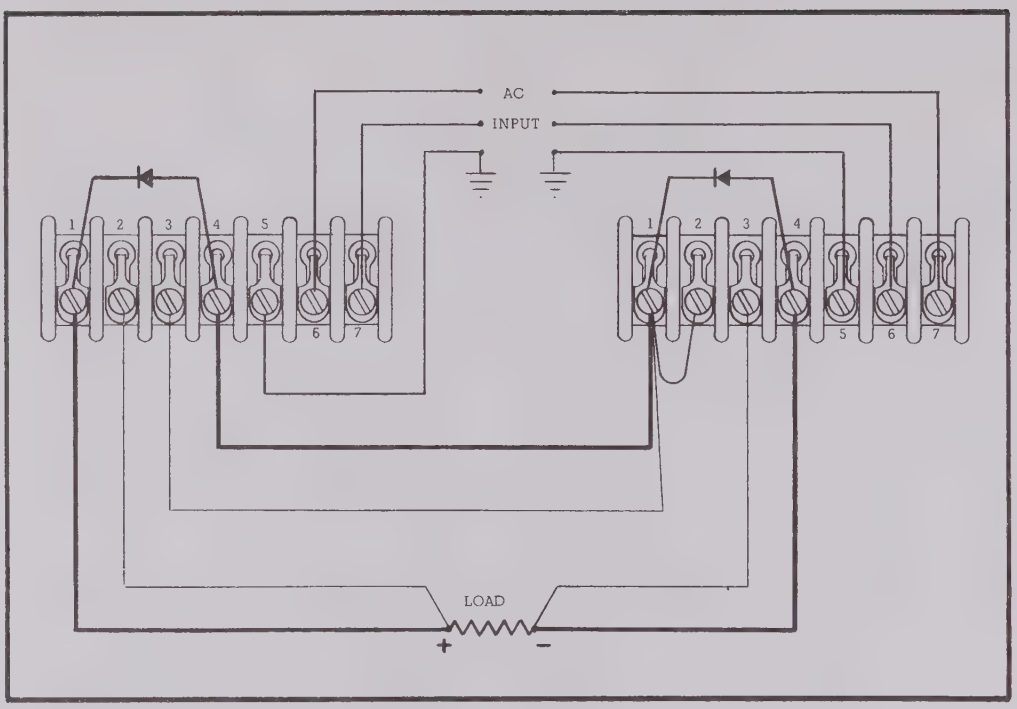


Figure 3-3. Series Operation Configuration

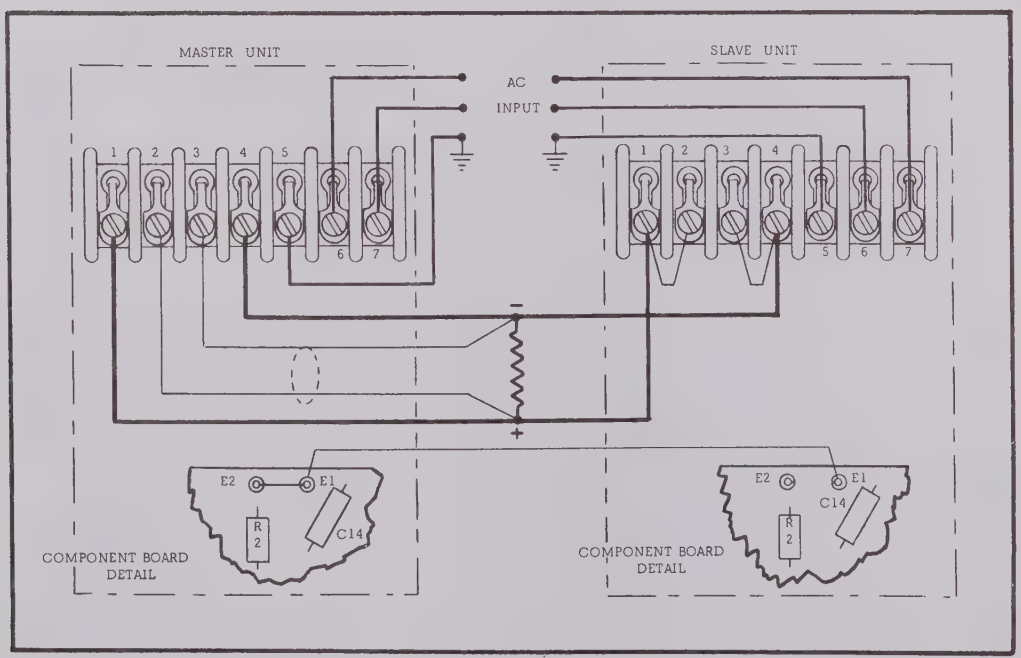


Figure 3-4. Parallel Operation Configuration

QSA MODEL	MANUFACTURER	MFR. PART NO.	SORENSEN PART NO.
18-1.1	Unitrode	RG118	587565-1
18-1.9	Semtech	3S11	587566-1
18-3.0	Semtech	3S11	587566-1
48-.4	Unitrode	RG118	587565-1
48-.8	Unitrode	RG118	587565-1
48-1.2	Unitrode	RG118	587565-1
75-.5	Unitrode	RG119	587565-2
75-.8	Unitrode	RG119	587565-2
120-.5	Unitrode	RG119	587565-2
175-.25	Unitrode	RG120	587565-3
265-.15	Unitrode	RG120	587565-3

Table 3-1. Series Rectifier Recommendations

4. THEORY OF OPERATION

4-1. GENERAL.

4-2. This section discusses unit operating principles. Its function is to impart a sufficient knowledge of the unit circuitry which, when used with the troubleshooting data in Section V, will enable the rapid isolation of unit faults.

4-3. Due to some minor differences betwen models within the QSA series, separate discussions of certain sections are provided. These will be noted as they appear.

4-4. PASSING-STAGE PRINCIPLE.

4-5. The QSA utilizes the series-passing-stage principle in regulating unit output. With this approach, a variable impedance absorbs the difference between the desired regulated output and the filtered "brute-force" dc. The variable impedance is provided by a transistor stage which is fed an output-related control signal. Passing stage operation is idealized in Figure 4-1.

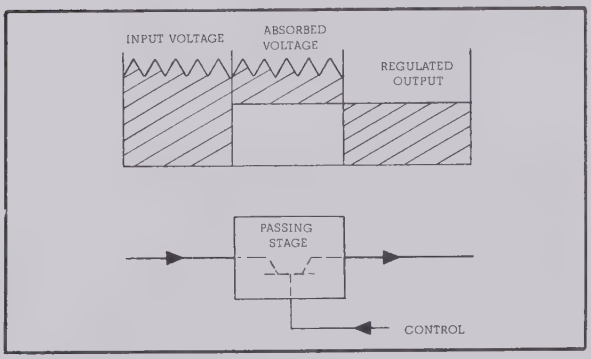


Figure 4-1. Passing-Stage Principle

4-6. BLOCK-DIAGRAM DISCUSSION.

4-7. Referring to Figure 4-2: the transformer steps down (or steps up in the case of 75- and 120-V units) the a-c input and applies it to a full-wave bridge rectifier. Output from the rectifier is fed through a passing stage to the load. This passing stage is, of course, the regulating device, absorbing the difference between the rectifier and desired output voltages. The feedback loop to the passing stage includes a sensing bridge, which compares a portion of the unit output against a fixed reference. Bridge-derived error signals, differentially amplified, vary the drive current to the passing stage, thereby changing stage impedance (and therefore IR drop) as a function of unit output.

4-8. Overcurrent protection is provided by the foldback section, which, in the event of a short circuit, overload or unit malfunction, reduces the drive on the passing stage by providing an alternate path for the current output of the constant-current generator.

4-9. SENSING AND ERROR AMPLICATION.

4-10. Output voltage sensing and error amplification are provided by a bridge circuit, consisting of resistor R9, reference diode CR8 and potentiometer R15, sensing resistor R18 (and R17 in high-voltage models) and differential amplifiers Q8, Q9 and Q6 and Q7. R10 and R11 are collector resistors; R8 and R13 are the emitter resistors for their respective amplifiers. Capacitor C6 and resistor R12 are used for amplifier stabilization. In the 48-, 75-, and 120-volt units, CR10 protects the bridge circuit from high reverse voltages developed during a short-circuit condition.

NOTE

See Figure 5-2 for schematic location of reference designations used throughout this section.

4-11. Operationally, the voltage reference, developed by the zener action of CR8, is compared with a portion of the output voltage sensed across an arm of the bridge, i.e., schematically the part of R15 across the base-emitter of Q9. Error signals, resulting from variations in unit output, are applied to the bases of Q8 and Q9. The operating currents in each transistor then change as a function of signal strength and polarity. (Note that the sum of the operating currents in Q8 and Q9 is kept approximately constant by the zener-diode regulated voltage across R13). Variations in voltages across the collectors, resulting from the current changes, produce an amplified potential difference between the bases of Q6 and Q7. The operating currents through Q6 and Q7 change, causing an increase or decrease of drive on the passing stage. For an illustration of circuit operation, refer to para. 4-18.

4-12. The voltage across R15 and therefore across the bridge is actually the voltage being regulated. It is therefore very nearly constant. As a result, the sum of the bridge and amplifier currents is constant. This total current produces an IR drop across R18 which, when added to th 7.9V across R15, gives the output voltage.

4-13. CONSTANT-CURRENT GENERATOR.

4-14. In para. 4-11, it was stated that the conduction level of Q6 is controlled by the operation of differential amplifier (Q8, Q9). Current through Q6 then is altered indirectly by varia-

tions in the output voltage. Q6's operating current and the drive current on Q4 are supplied by the constant-current generator. As a result any change in the operating current in Q6 is reflected as an increase or decrease in the drive on Q4. This is the key to feedback control.

4-15. The generator is comprised of two resistors (R1 and R2), two diodes (CR2 and CR3), and transistor Q5. The diodes act as voltage regulators and provide the current-limiting characteristic by holding the voltage drop across R1 constant. Input to the generator is derived from an unregulated supply consisting of a secondary winding of T1, half-wave rectifier (CR1) and filter capacitor C1.

4-16. DRIVERS AND PASSING STAGES.

4-17. The drivers for passing stage (Q2) are transistors Q3 and Q4. As may be recalled, the constant-current generator supplies drive current to Q4 and operating current for Q6. The drive on Q4 is amplified by a high-gain circuit and applied to the base of Q2, altering stage impedance and therefore its IR drop as a function of unit output. It should be noted that most models have two parallel-connected passing stages (Q2a and Q2b). Resistors R7A and B insure equal current sharing by their respective transistors. In the QSA 120-.5 model, the passing stages are connected in series and equally share the total voltage absorbed across the stages. The voltage-sharing circuit is made up of divider R29, R30 and amplifier Q4A. As an example of circuit operation, assume that 215-Vdc output of the unregulated supply increases (either through a line or load variation). R29 and R30 divide the increase equally and a voltage signal, amplified by Q4A, is placed across the base-emitter of Q2A. Q2A's impedance increases until its absorbed voltage is equal to that developed across R29. The voltage absorbed by Q2B then is equal to the voltage across the divider minus the drop across Q2A and CR11, and it is controlled by action of the sensing and amplifier section. CR11 and R3A form a reverse-bias section for Q2A.

4-18. CIRCUIT OPERATION.

4-19. As an example of how sensing and error amplification, the constant-current generator, and the drivers and passing stages function to regulate the output voltage, assume that the output tends to rise. The increase in voltage is sensed across R15, and therefore the base of Q9 becomes more positive with respect to the base of Q10. The operating current through Q9 increases, and the voltage drop across R11 becomes greater. The base of Q7, therefore, becomes more negative with respect to the base of Q6, Q7 conducts less current, and more current is drawn through Q6. With an increase in Q6 operating current, the drive current to Q4 is reduced since the sum of these currents is fixed by the constant-current generator. Reduction of the drive on Q4 decreases Q4's operating current. This reduces the drive on Q3 and subsequently the drive on Q2. Q2's impedance, and therefore its absorbed voltage increases, and the output is regulated to the desired output.

4-20. INPUT-POWER SECTION.

4-21. The input-power section includes main transformer (T1), a full-wave bridge rectifier (CR4-CR7), and filter capacitor C3. (In the 48-, 75-, and 120-volt models, resistor (R28) connected across C3 serves as a bleeder). Capacitor C19 (48-, 75-, or 120-volt models) connected across the input terminals is a high-frequency by-pass, and capacitor C2 suppresses noise generated by rectifier commutation.

4-22. CURRENT-FOLDBACK SECTION.

4-23. Overcurrent protection is afforded by the current-foldback section, which is comprised of voltage divider (R5 and R6), sensing resistor (R7) and transistor (Q5). During an overcurrent condition, the section operates to pull current from the constant-current generator. This effectively decreases the drive on Q4, and subsequently increases passing-stage impedance. The absorbed voltage across the stage increases and consequently the output voltage and current decrease.

4-24. More explicitly, an overcurrent condition generates a higher voltage drop across R7. When the difference between this drop and the voltage across R5 is sufficient (approximately 0.6V), Q5 conducts and pulls current from the constant-current generator. This reduces the drive on Q2, increasing its impedance and subsequently decreasing the output voltage. As the output voltage drops, the load current will decrease. A dropping output voltage and decreasing current reduce the voltage drops across both R7 and R5, until these voltage are nearly equal.

4-25. STABILIZATION.

4-26. Inherent in the operation of any high-gain feedback amplifier is the tendency for it to become unstable under certain operating conditions. To preclude unstable operation in the QSA amplifiers, a number of stabilization capacitors and a resistor have been connected across appropriate points. The capacitors include C4, C5, C7, C8, C9, and C14. C20, in the 120-.5 model, also performs the same function. Resistor R12 and capacitor C6 form a stabilization network.

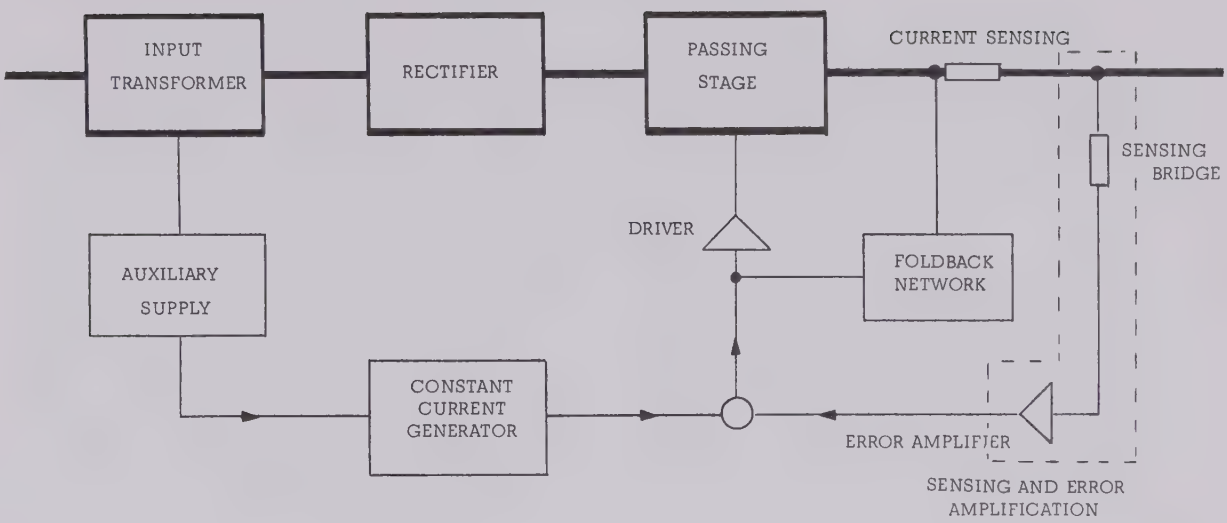


Figure 4-2. Block Diagram

5. SERVICE AND REPAIR

5-1. GENERAL.

5-2. This section provides troubleshooting data, periodic servicing, and calibration and performance-testing procedures. The troubleshooting data should be used in conjunction with both the schematic diagram (Figure 5-2) which tabulates voltage-check points, and Section IV, which outlines the principles of operation. In addition, Figures 5-1 and 5-3 physically locate the parts appearing on the schematic. Any questions pertaining to repair should be directed to the nearest Sorensen representative (a list is included with the unit) or to the Service Dept., Sorensen Company, 676 Island Pond Road, Manchester, N.H. 03103. Include the model and serial numbers in any correspondence. Should it be necessary to return a unit to the factory for repair, authorization from the Sorensen Service Department must be obtained first. Sorensen Company will not assume responsibility for units returned without prior authorization.

5-3. PERIODIC SERVICING.

5-4. The QSA models require no periodic servicing. However, it is recommended that whenever a unit is taken off the line, the enclosure be inspected and cleaned of any accumulation of dust or other debris which could impede natural air flow through unit.

5-5. TROUBLESHOOTING.

5-6. Table 5-1 lists a number of malfunctions symptoms and their probable causes. The table covers symptoms which are attributable to a single component failure only. This should not be interpreted to mean that there could not be other causes for the tabulated symptoms. Footnotes in the table indicate which components may be damged due to "chain-reaction" effect. If any amplifier components are replaced, unit may require recalibration. Refer to para. 5-7.

SYMPTOM	PROBABLE CAUSE (1)(2)
No Output	a. Transistor Q1, Q2, Q3 or Q4 open.
	b. In QSA model 120-.5, transistor Q4A open.
	c. Diode CR1 open.
	d. Transistor Q5 shorted.
High Output	a. In constant-current generator, transistor Q1 shorted, or diode CR2 or CR3 open.
	b. Driver Q3 or Q4 shorted. (2)
	c. Passing stage Q2 shorted.
	d. Potentiometer R15 or R18 defective.
	e. Amplifier transistor Q6 or Q9 open.
	f. Amplifier transistor Q7 or Q8 shorted.
	g. Zener reference diode CR8 open.
Low Output	In constant current supply, diode CR1 shorted.
	In amplifier, transistor Q6 or Q9, or zener diode CR8 shorted.
	In amplifier, transistor Q7 or Q8 open.
	In foldback circuit, transistor Q5 shorted.
Foldback Circuit Inoperative (3)	Transistor Q5 open.
User-supplied Input Protective Device Actuates	Shorted CR4, CR5, CR6, or CR7.
Ripple Specifications Degenerate	Open CR4, CR5, CR6, or CR7.(4)

(1) Parallel passing stage, if any, may be damaged as a result of an open Q2.
(2) When replacing Q2, apply thermal junction compound (Thermacote, Thermalloy Co., Dallas, Texas or an equivalent) to both sides of wafer. Mounting-screw torque is 10 lb-in.
(3) Without foldback, no protection is provided for the passing stage, bridge rectifiers or input transformer. If any of these components fail, check the foldback circuit before returning unit to service.
(4) Complementary rectifer will be overloaded if one of the bridge rectifiers opens. Check before returning unit to service.

Table 5-1. Troubleshooting Data

5-7. CALIBRATION.

5-8. Calibration entails the checking and, if necessary, the adjustment of the comparison-bridge and current-foldback circuits.

5-9. COMPARISON BRIDGE. To check and, if required, adjust the comparison-bridge circuit, proceed as follows:

a. Rotate Output Adjust to approximately the midrange position.

b. Remove unit nameplate and side-enclosure plate.

c. Turn bridge-voltage potentiometer shaft (normally concealed by nameplate) to the midrange position.

d. Connect a sensitive d-c voltmeter (0 -10V range) across terminal 2 (+ SENSE) and terminal stud E3 on component board.

e. Assure that links are firmly in place across terminals 1 and 2, 3 and 4.

f. Apply a nominal 115V input to terminals 6 and 7. Voltmeter should indicate between 7.8 and 8 volts. If it does not, use potentiometer R15 to adjust.

g. Remove input power, and reconnect voltmeter across terminals 1 and 4. Select a voltmeter range compatible with unit output ratings.

h. Apply nominal input power and rotate Output Adjust from stop-to-stop. At left-hand stop, voltmeter should indicate no more than the minimum value of the unit's specified range, and at right-hand stop, at least the maximum value.

i. Remove input, disconnect voltmeter, and before remounting enclosure, apply locking compound to potentiometer R15.

5-10. CURRENT FOLDBACK. Current-foldback recalibration procedures are identical to those listed under para. 3-9. Table 5-2 lists recommended foldback settings for all QSA models covered in this manual.

QSA Model	FOLDBACK SETPOINT, (A dc) (0 - 40°C)	REGULATION (mV)
18-1.1	1.5	1.8
18-1.9	2.6	1.8
18-3.0	4.1	1.8
48-.4	0.55	4.8
48-.8	1.1	4.8
48-1.2	1.65	4.8
75-.5	0.69	7.5
75-.8	1.1	7.5
120-.5	0.69	24.0
175-.25	0.35	35.0
265-.15	0.22	53.0

Table 5-2. Calibration and Performance Data

5-11. PERFORMANCE TESTING.

5-12. OUTPUT RIPPLE. To measure output ripple, proceed as follows:

a. Connect a test set-up as shown in Figure 5-8. Set oscilloscope for 0.5 mV vertical and 10ms/cm horizontal. (Oscilloscope should have at least a 30MHz bandwidth). Select a 150V range for a-c voltmeter. Choose a 0.5 mV range for RMS meter and a range for the d-c ammeter compatible with unit's rated output current. Use a resistive load with a current-drawing capacity greater than unit's rated output. Use the differential voltmeter as a VTVM. Select a 15-volt range.

b. At no load, apply a 115-Vac, 60Hz input, and adjust to the nominal output voltage (indicated by first two or three digits of unit model number).

c. Apply load and observe oscilloscope and RMS voltmeter. Voltmeter should indicate no more than 0.3 mV; oscilloscope should display a peak-to-peak voltage no greater than 3 mV.

d. If desired, check regulation per para. 5-13.

5-13. REGULATION. To measure unit's output regulation, proceed as follows:

a. Connect unit to test set-up shown in Figure 5-4. The oscilloscope and RMS voltmeter are not necessary. Convert the voltmeter to the differential mode. Select an internal voltage equal to the unit's nominal output voltage, and set null sensitivity to the 10 mV or 20 mV range (QSA 120-.5 model).

b. Apply a 115-Vac, 60Hz input, and adjust output voltage to obtain a null indication on voltmeter.

c. With a-c voltmeter indicating 115-Vac, increase load on unit until d-c ammeter reads current equal the maximum rated current at 40°C. Record the deviation from voltmeter null position.

d. Adjust voltmeter internal voltage to regain the null position. Then with full load on unit, vary input voltage at 60Hz from 105 to 125 Vac. Note the deviation.

e. Sum the deviations recorded in steps c and d. The total should be less than the regulation voltage tabulated in Table 5-2 for the model under test.

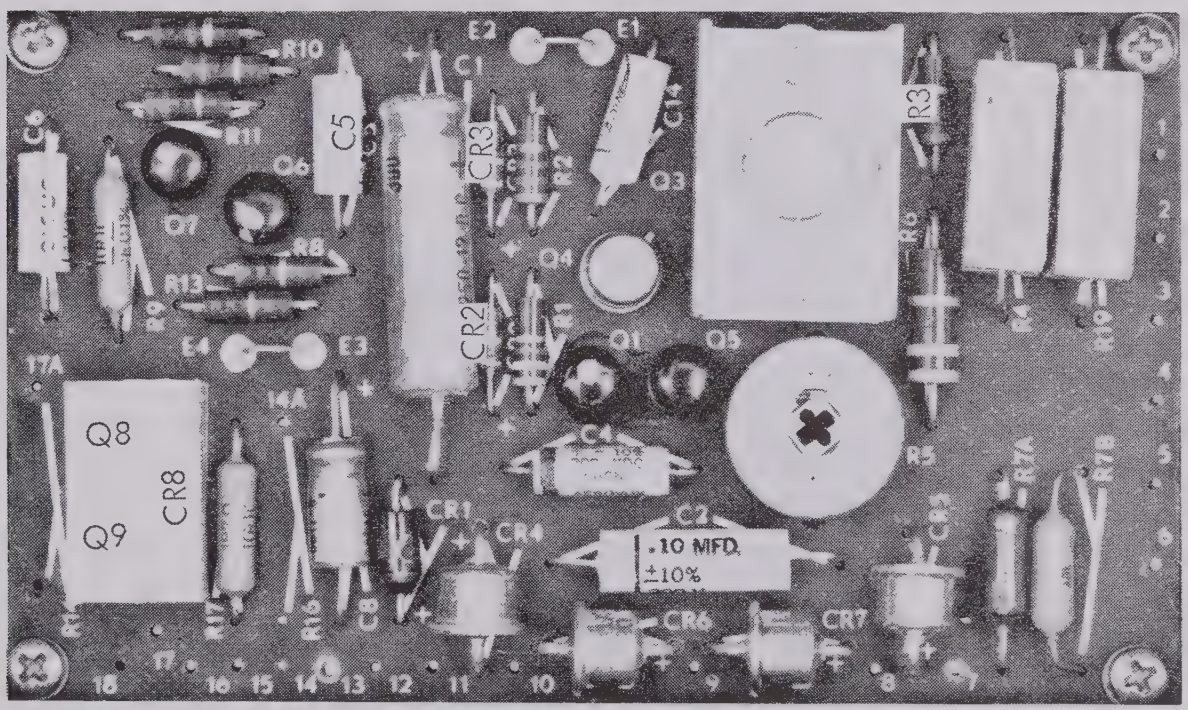


Figure 5-1. Component Board (typical)

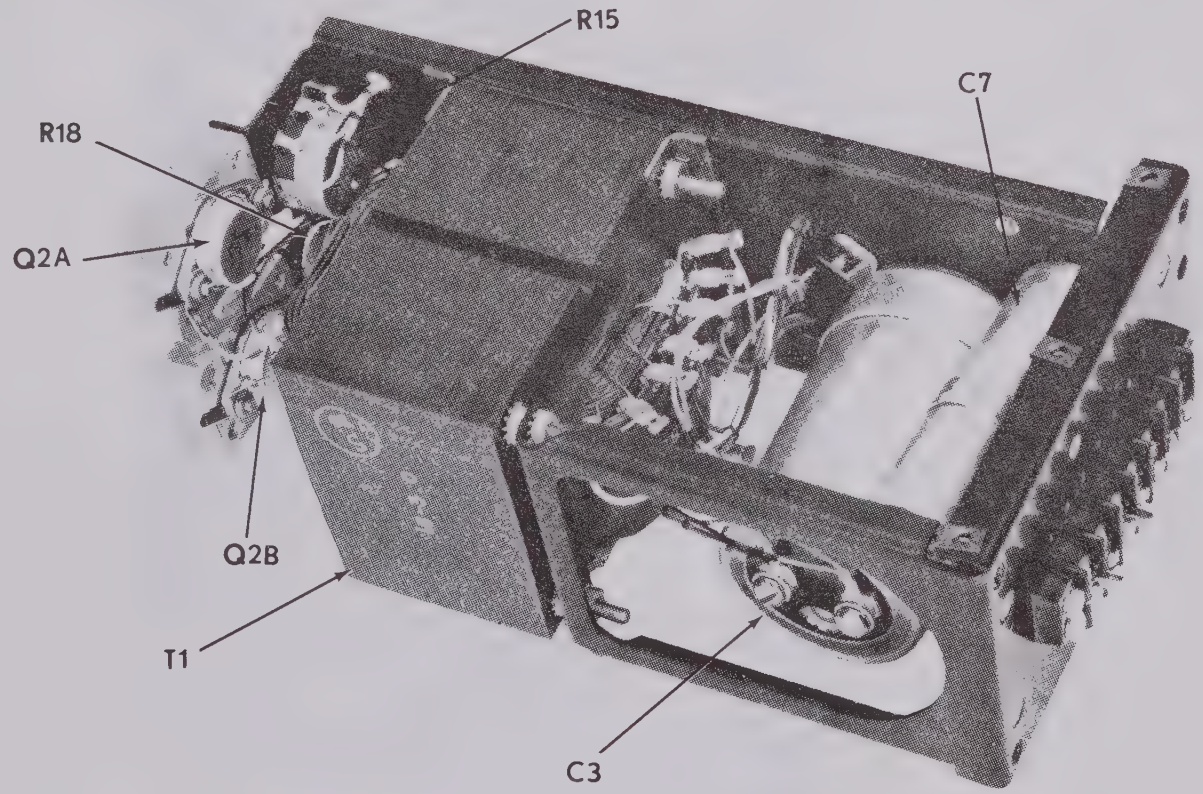
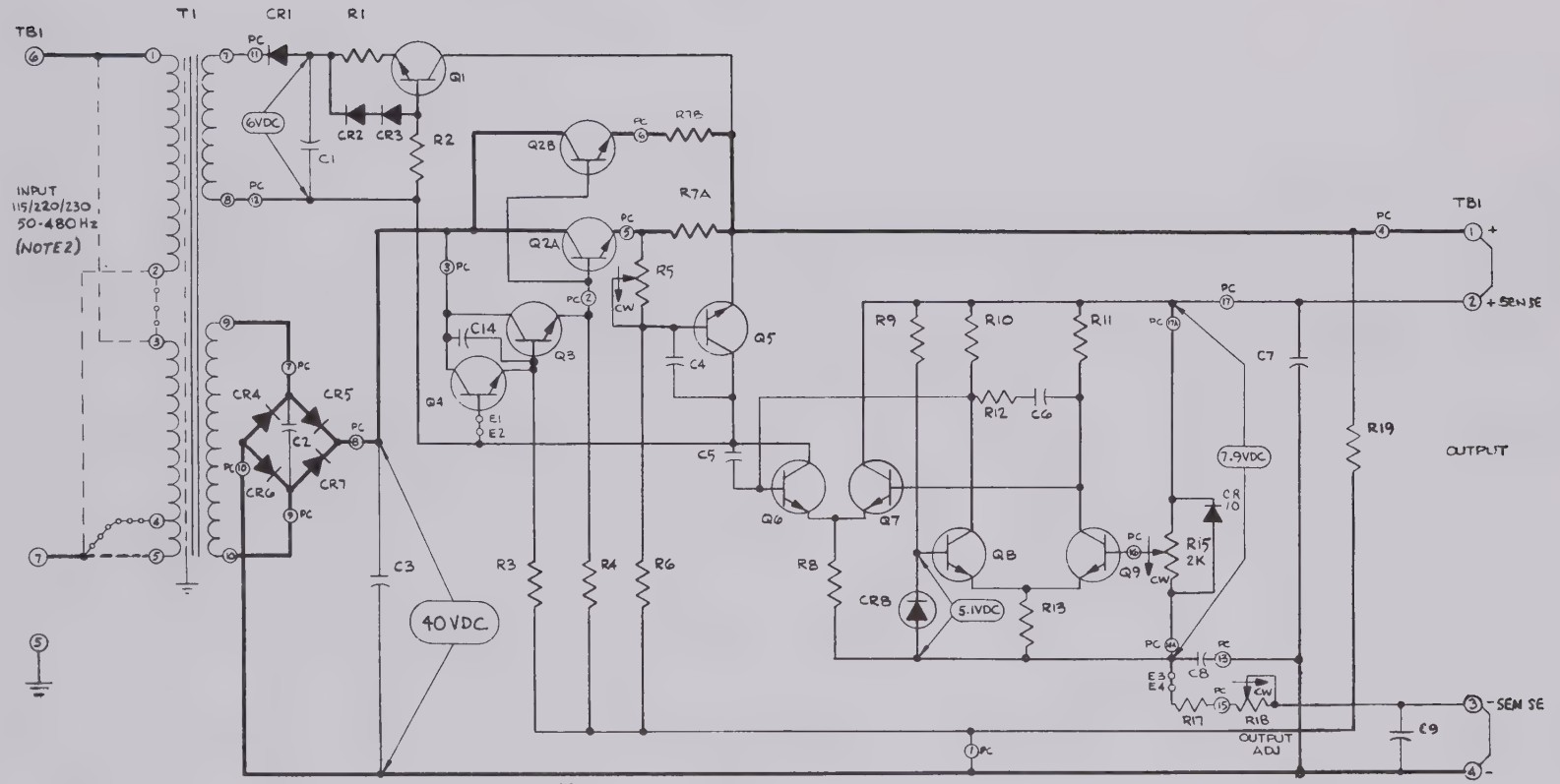


Figure 5-2. Partial Disassembly (typical)



NOTES:

1. ALL VOLTAGES MEASURED AT NOMINAL INPUT, NOMINAL OUTPUT, NO LOAD
2. SEE FIGURE 2-1 FOR INPUT CONNECTIONS

Figure 5-3. Schematic Diagram, 18 Volt Model

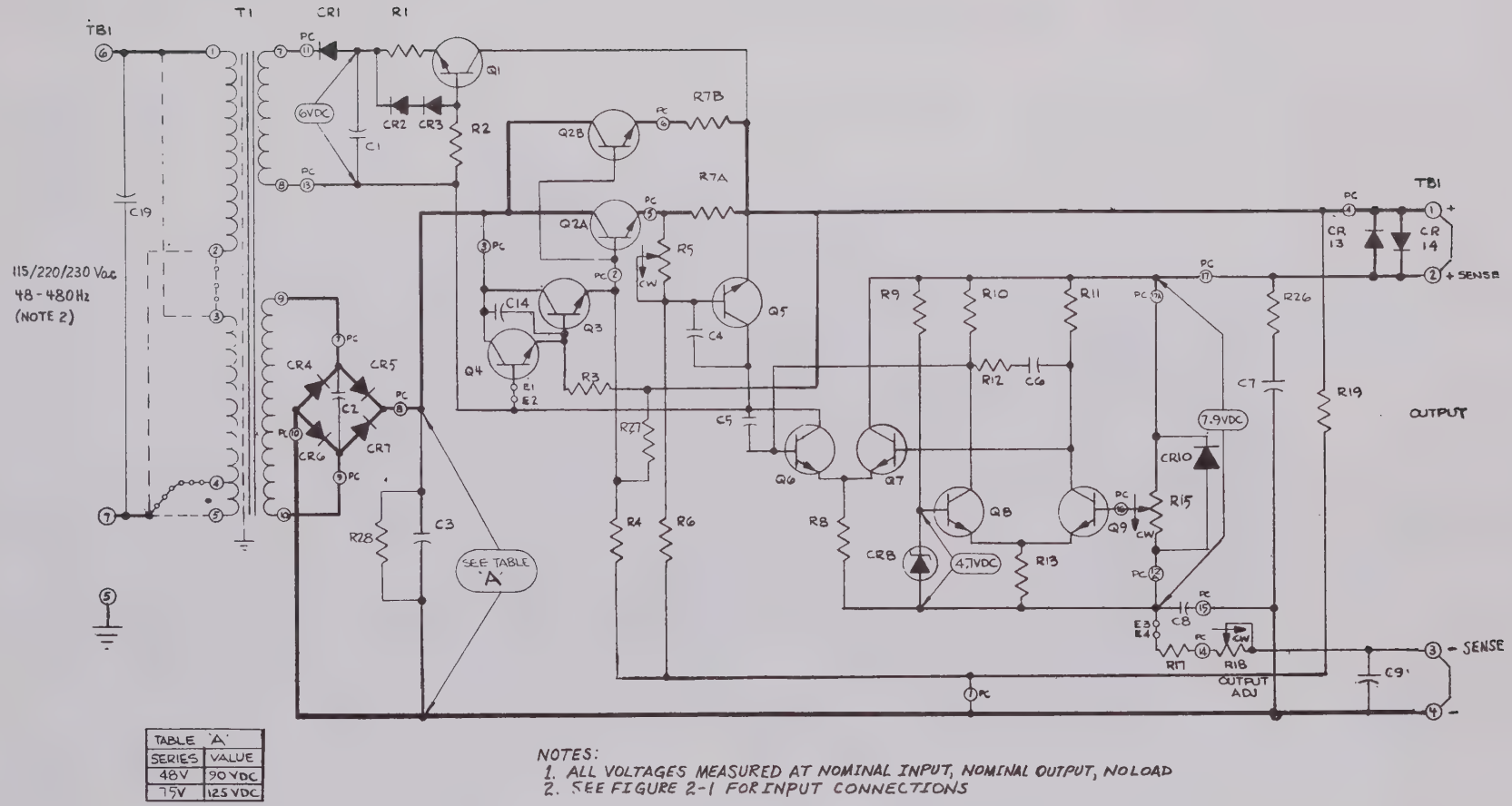
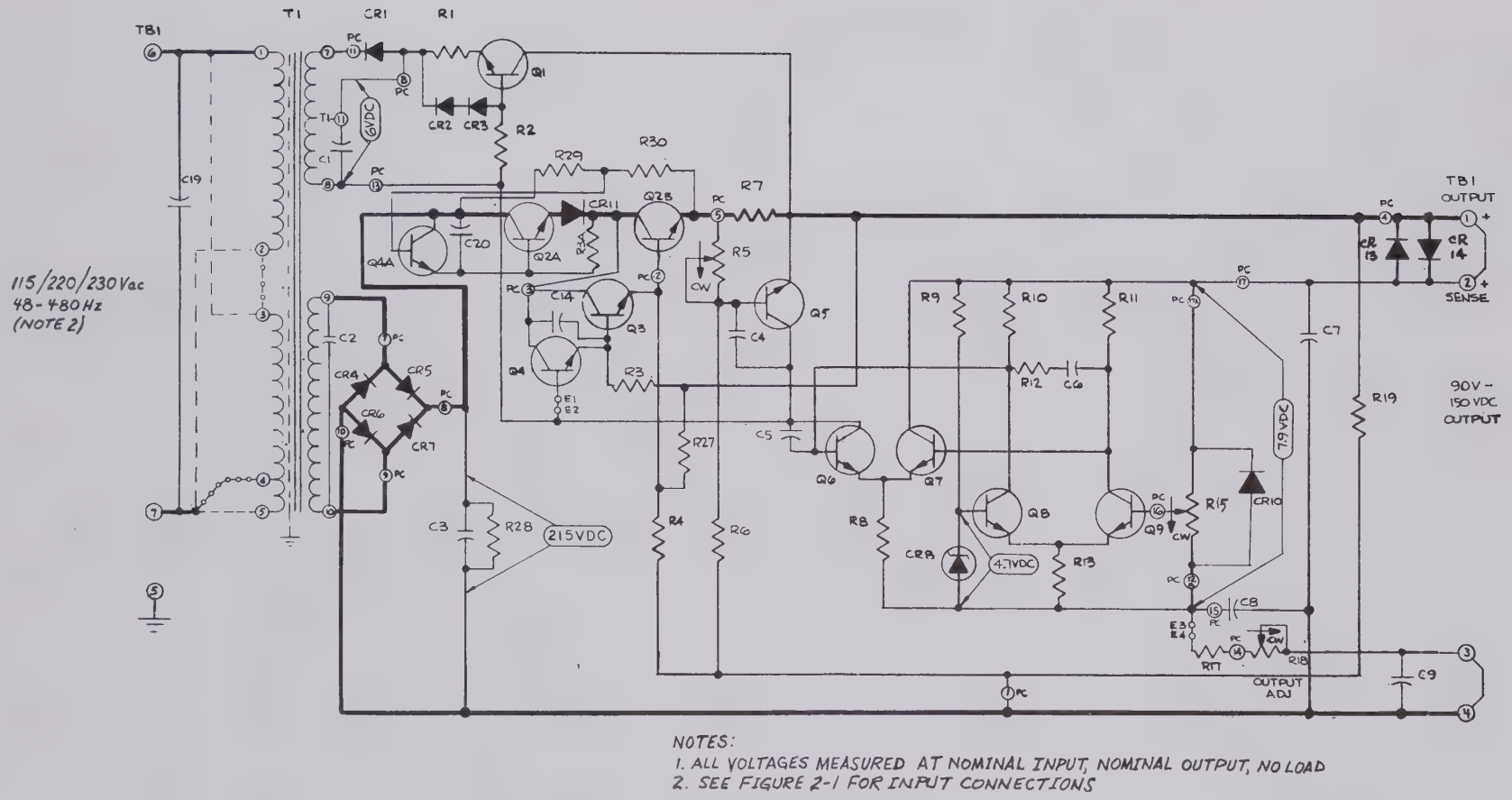
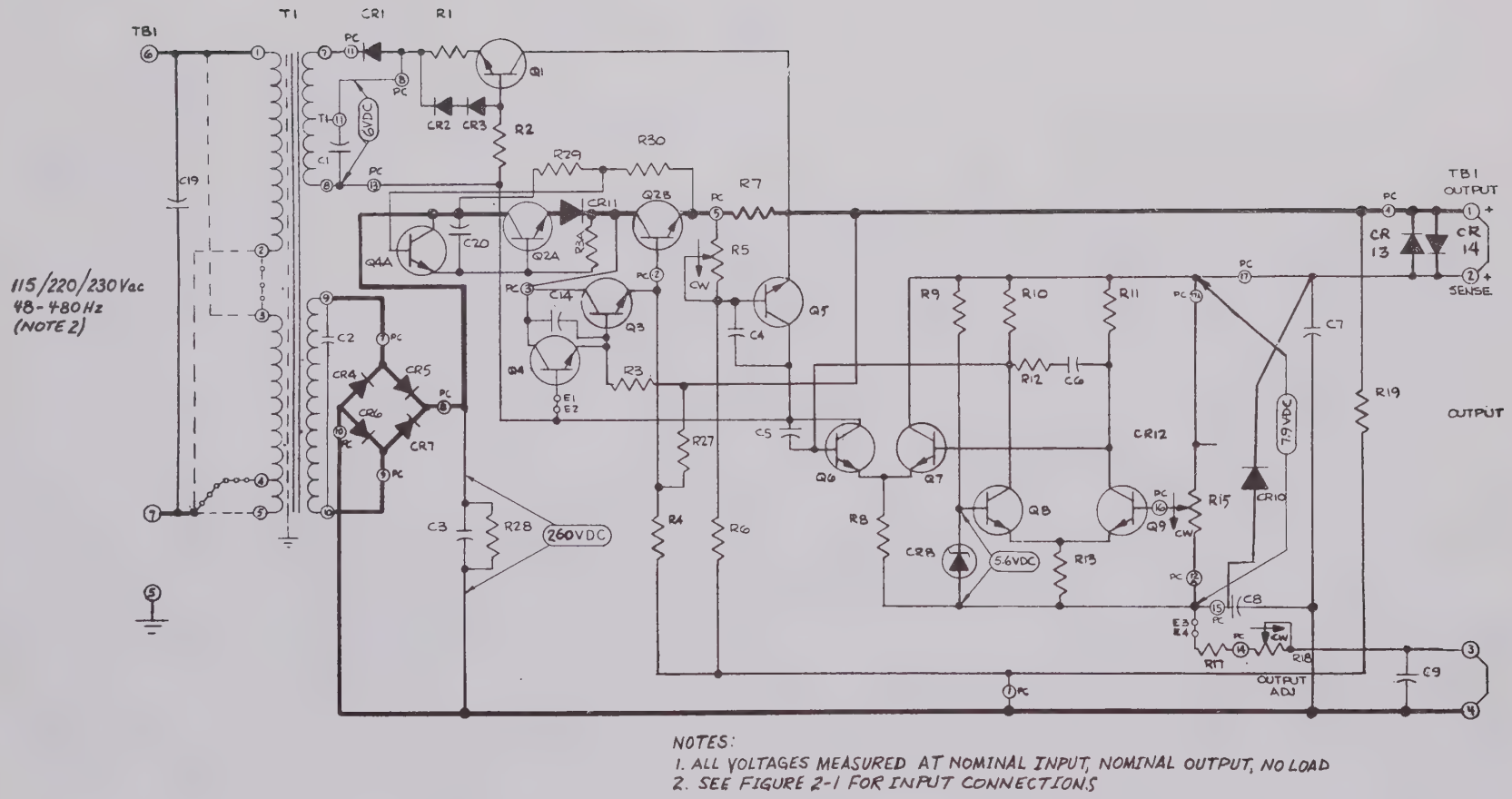


Figure 5-4. Schematic Diagram, 48 and 75 Volt Models



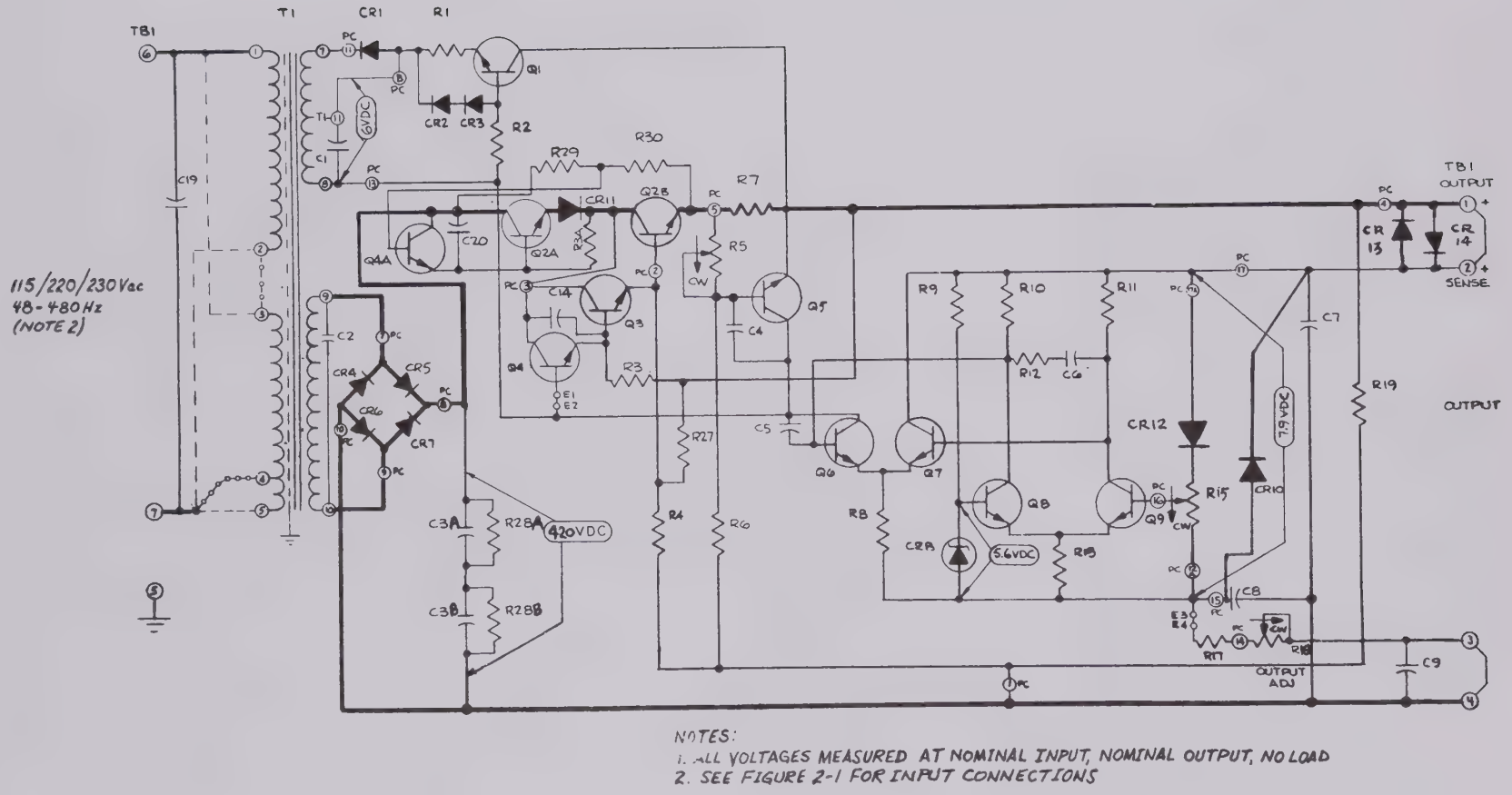
C200-4064 REV D

Figure 5-5. Schematic Diagram, 120 Volt Model



C200-4143 REV E

Figure 5-6. Schematic Diagram, 175 Volt Model



C200-4142 REV D

Figure 5-7. Schematic Diagram,265 Volt Model

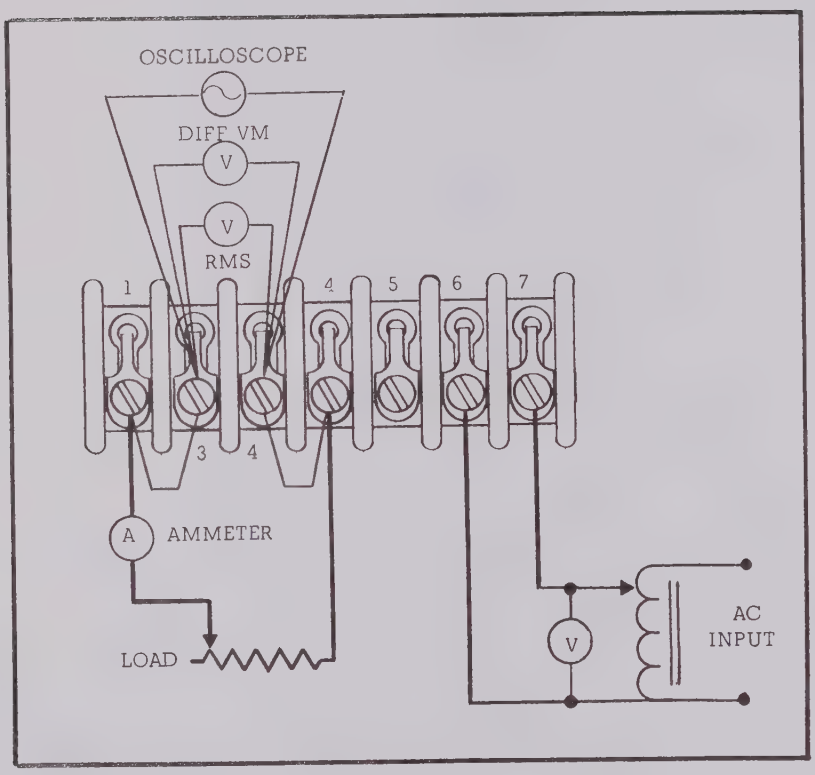


Figure 5-8. Performance Test Setup

6. REPLACEABLE PARTS LIST

6.1 INTRODUCTION

This section provides replacement parts lists for the QSA power supplies. The lists are keyed to the schematic diagrams (Figures 5-2 through 5-6) and the parts locating photographs (Figures 5-1 and 5-7). Table 6-1 lists parts for the covered QSA models.

6.2 TABLE HEADINGS DEFINED

6.2.1 Circuit Symbol

This is an alpha-numeric identification of the component as called out on the unit drawings.

6.2.2 Sorensen Part Number

This number should be used when ordering parts directly from:

Sorensen Company
Replacement Parts Dept.
676 Island Pond Road
Manchester, N. H. 03103

6.2.3 Manufacturer Type

This is the basic group or series under which the part is listed by a manufacturer. The coded identification of manufacturer is listed below alphabetically.

MANUFACTURER CODES

Mfr. Code	Manufacturer
AB	Allen Bradley Company
AX	Acushnet Capacitor Company
CS	Clarostat Manufacturing Co., Inc.
CTS	CTS Corporation
FC	Fairchild Semiconductor
IRC	International Resistance Co.
MA	Motorola Semiconductor Products
RCA	Radio Corporation of America
RDM	Radio Material Co. Div. P. R. Mallory
SEN	Sensitron Semiconductor
SG	Sage Electronics
SP	Sprague Electric Co.
SR	Sorensen Company
ST	Solitron Devices Inc.
WL	Ward Leonard Electric Co.

Table 6-1
Replacement Parts List

CIRCUIT SYMBOL	QSA Models 18-1.1	18-1.9	18-3.0	48-.4	48-.8	48-1.2	75-.5	75-.8	120-.5	175-.25	265-.15	DESCRIPTION	SORENSEN PART NUMBER	MANUFACTURER, TYPE
												Capacitors (uF unless noted)		
C1	x	x	x	x	x	x	x	x	x	x	x	250, 12V	235-7404P20	SP, DF
C2	x			x	x	x	x	x				0.1, 200V	24-2409-13	AC, V146XR
		x	x									0.1, 400V	235-7440P7	S-T, HW
								x				0.1, 400V	24-2411-13	
									x	x		0.02, 900V	24-026	RDM, U026MV
C3	x											700, 50V	24-2456-2	SP, 34D
		x										1700, 50V	24-2445-6	SP, 32D
			x									4700, 40V	24-2460-2	SP, 39D
				x								270, 100V	24-2443-1	SP, 36D
					x							600, 150V	24-2466-1	SP, 36D
						x						1200, 150V	24-2466-2	SP, 36D
							x					420, 200V	24-2467-1	SP, 36D
								x				950, 200V	24-2467-2	SP, 36D
								x				550, 300V	24-2468-1	SP, 36D
									x			150, 350V	24-2572-1	SP, 32D
											x	160, 400V (2 Required)	24-2573-1	SP, 32D
C4	x	x	x	x	x	x	x	x	x	x	x	0.01, 200V	24-2409-7	AX, V146XR
C5	x	x	x	x	x	x	x	x	x	x	x	0.0068, 200V	24-2409-6	AX, V146XR
C6	x	x	x	x	x	x	x	x	x	x	x	0.015, 200V	24-2409-8	AX, V146XR
C7	x											600, 40V	24-2453-2	SP, 34D
		x										800, 40V	24-2453-3	SP, 34D
			x									1100, 40V	24-2453-4	SP, 34D
				x	x		x					150, 100V	24-2463-1	SP, 34D
						x		x				250, 100V	24-2463-2	SP, 34D
								x				140, 200V	24-2465-1	SP, 34D
									x			62	24-2574-1	SP, 34D
											x	40	24-2576-1	SP, 34D
C8	x	x	x									4, 50V	235-7404P38	SP, DF
				x	x	x	x	x				4, 100V	235-7404P12	SP, TE1403
								x				5, 150V	24-2464-1	SP, 34D
									x	x		4	24-2575-1	SP, 34D
C9	x	x	x	x	x	x	x	x	x	x	x	0.01, 200V	24-2409-9	AX, V146XR
C14	x	x	x									0.0022, 200V	24-2409-3	AX, V146XR
				x	x	x	x	x	x	x	x	0.01, 200V	24-2409-7	AX, V146XR
C19	x	x	x									Not Used		
				x	x	x	x	x	x	x	x	0.02, 900V	24-026	RDM, U026MV
C20								x	x	x		0.01, 200V	24-2409-7	AX, V146XR
												Diodes		
CR1	x	x	x	x	x	x	x	x	x	x	x	SEN-R-28	587565-1	SEN
CR2	x	x	x	x	x	x	x	x	x	x	x	RD 5637	26-1017	SR
CR3	x	x	x	x	x	x	x	x	x	x	x	RD 5637	26-1017	SR
CR4	x											SEN-R-28	587565-1	SEN
		x	x									MR-1031A	26-1006-2	MA
				x	x	x	x	x				SEN-R-29	587565-2	SEN
								x				SEN-R-30	587565-3	SEN
									x			SEN-R-31	587565-4	SEN
											x	SEN-R-32	587565-5	SEN
CR5	x											SEN-R-28	587565-1	SEN
		x	x									MR-1031A	26-1006-2	MA
				x	x	x	x	x				SEN-R-29	587565-2	SEN
								x				SEN-R-30	587565-3	SEN
									x			SEN-R-31	587565-4	SEN
											x	SEN-R-32	587565-5	SEN
CR6 &	x											SEN-R-28	587565-1	SEN
CR7		x	x									MR-1031A	26-1006-2	MA
				x	x	x	x	x				SEN-R-29	587565-2	SEN
								x				SEN-R-30	587565-3	SEN

Table 6-1
Replacement Parts List (cont'd)

CIRCUIT SYMBOL	QSA Models 18-1.1	18-1.9	18-3.0	48-.4	48-.8	48-1.2	75-.5	75-.8	120-.5	175-.25	265-.15	DESCRIPTION	SORENSEN PART NUMBER	MANUFACTURER, TYPE
												Diodes (cont'd)		
(cont'd)														
CR6 & CR7									x	x		SEN-R-31 SEN-R-32	587565-4 587565-5	SEN SEN
CR8	x	x	x	x	x	x	x	x	x	x		1N750 Zener, 4.7V 1N5232B	26-211 588101-8	MA MA
CR10	x	x	x	x	x	x	x	x	x	x		SEN-R-28	587565-1	SEN
CR11								x	x	x		SEN-R-28	587565-1	SEN
CR12									x	x		SEN-R-28	587565-1	SEN
CR13	x	x	x									Not Used		
				x	x	x	x	x	x	x		SEN-R-28	587565-1	SEN
CR14	x	x	x									Not Used		
				x	x	x	x	x	x	x		SEN-R-28	587565-1	SEN
												Transistors		
Q1	x	x	x	x	x	x	x	x	x	x		FSC 3641	18-144	FC
Q2A	x	x	x									2N3055	18-151	RCA
				x	x	x	x	x				2N3442	18-163	RCA
									x			2N5239	18-198-1	RCA
										x		2N5239	18-198-2	RCA
Q2B	x			x								Not Used		
		x	x									2N3055	18-151	RCA
					x	x	x	x	x			2N3442	18-163	RCA
									x			2N5239	18-198-1	RCA
										x		2N5239	18-198-2	RCA
Q3	x	x	x									40312	18-142	RCA
				x	x	x	x	x	x			40313	18-164	RCA
									x			40313, Selected	18-196-1	RCA
										x		40313, Selected	18-196-2	RCA
Q4	x	x	x									2N3019	386-7316P1	RCA
				x	x	x	x	x	x			40321	18-165	RCA
									x			40321, Selected	18-197-1	RCA
										x		40321, Selected	18-197-2	RCA
Q5	x	x	x	x	x	x	x	x	x	x	x	2N697	18-115	RCA
Q6	x	x	x	x	x	x	x	x	x	x	x	FSC 3641	18-144	FC
Q7	x	x	x	x	x	x	x	x	x	x	x	FSC 3641	18-144	FC
Q8	x	x	x	x	x	x	x	x	x	x	x	FSC 3641	18-144	FC
Q9	x	x	x	x	x	x	x	x	x	x	x	FSC 3641	18-144	FC
												Resistors (ohms, 1/2W unless noted)		
R1	x	x	x	x	x	x	x	x	x	x	x	390	280-1145P59	AB, EB
R2	x	x	x	x	x	x	x	x	x	x	x	680	280-1145P68	AB, EB
R3	x	x	x									8.2K	27-1163	AB, EB
				x	x	x	x	x	x	x	x	270	280-1145P53	AB, EB
R4	x											600, 5W	27-458	CS, C5GL
		x	x									300, 5W	27-457	CS, C5GL
				x	x	x						2K, 5W	27-499-15	CS, C5GL
							x	x				6.8K, 2W	280-1147P104	AB, HB
									x			22K, 2W	280-1147P122	AB, HB
										x		56K, 2W	280-1147P137	AB, HB
											x	120K, 2W	280-1147P149	AB, HB
R5	x	x	x	x	x	x	x	x	x	x	x	400,3W, Variable	29-489	CTS, HC-110
R6	x	x	x									3.3K, 1W	280-1180P91	AB, GB
				x	x	x						10K, 1W	280-1180P110	AB, GB
							x	x				22K, 1W	280-1180P122	AB, GB
									x			22K, 2W	280-1147P122	AB, HB
										x		56K, 2W	280-1147P137	AB, HB

Table 6-1
Replacement Parts List (cont'd)

CIRCUIT SYMBOL	QSA Models 18-1.1	18-1.9	18-3.0	48-.4	48-.8	48-1.2	75-.5	75-.8	120-.5	175-.25	265-.15	DESCRIPTION	SORENSEN PART NUMBER	MANUFACTURER, TYPE
												Resistors (ohms, 1/2W unless noted - cont'd)		
(cont'd)														
R6											x	82K, 2W	280-1147P143	AB, HB
R7A	x											1.0, 3W	27-297-25	WL, 3X
		x										1.1, 3W	27-397-26	WL, 3X
			x									0.68, 4W	27-1534-2	WL, 4X
				x	x		x					2.7, 3W	27-397-35	WL, 3X
						x						1.8, 3W	27-397-31	WL, 3X
							x		x			4.3, 3W	27-397-40	WL, 3X
								x				2.2, 3W	27-397-33	WL, 3X
										x		6.8, 3W	27-397-45	WL, 3X
R7B	x			x					x	x	x	Not Used		
		x										1.1, 3W	27-397-26	WL, 3X
			x									0.68, 4W	27-1534-2	WL, 4X
				x			x					2.7, 3W	27-397-35	WL, 3X
					x							1.8, 3W	27-397-31	WL, 3X
						x						4.3, 3W	27-397-40	WL, 3X
R8	x	x	x	x	x	x	x	x	x			1.2K	280-1145P77	AB, EB
									x	x		1.21K, 1/4W	28-1339	IRC, CEB-TO
R9	x	x	x	x	x	x	x	x	x			182	28-1212	IRC, CEC-TO
									x	x		887	28-1216	IRC, CEC-TO
R10	x	x	x	x	x	x	x	x	x			1.8K	280-1145P83	AB, EB
									x	x		1.5K, 1/4W	28-1340	IRC, CEB-TO
R11	x	x	x	x	x	x	x	x	x			1.8K	280-1145P83	AB, EB
									x	x		1.5K, 1/4W	28-1340	IRC, CEB-TO
R12	x	x	x	x	x	x	x	x	x	x	x	120	280-1145P41	AB, EB
R13	x	x	x	x	x	x	x	x	x			2.2K	280-1145P86	AB, EB
									x	x		2.4K, 1/4W	28-1341	IRC, CEB-TO
R15	x	x	x	x	x	x	x	x	x			2K, 4W, Variable	29-486	CS, 45
									x	x		4K, 4W, Variable	29-507	CS, 45
R17	x	x	x									182	28-1213	IRC, CEC-T2
				x	x	x						820, 3W	28-1204	SG, 1200S-820-5
						x	x					1.5K, 3W	28-1239	SG, 1200S-1500-3
								x				2.7K, 5W	28-1240	SG-1500S-2700-3
									x			11.9K, 5W	586054-70	Ohmite 555S
										x		16.2K, 5W	586054-71	Ohmite 555S
R18	x	x	x									600, 4W, Variable	29-484	CS, 45
				x	x	x						2K, 4W, Variable	29-486	CS, 45
							x	x				2.5K, 4W, Variable	29-506	CS, 45
									x			4K, 4W, Variable	29-507	CS, 45
									x			8K, 4W, Variable	29-553	CS, 45
										x		8.5K, 4W, Variable	29-554	CS, 45
R19	x											560, 2W	27-1164	AB, HB
		x	x									300, 5W	27-457	CS, C5GL
				x								3K, 5W	27-499-11	CS, C5GL
					x	x						1K, 5W	27-499-9	CS, C5GL
							x	x				10K, 2W	280-1147P110	AB, HB
									x			22K, 2W	280-1147P122	AB, HB
										x		56K, 2W	280-1147P137	AB, HB
											x	120K, 2W	280-1147P149	AB, HB
R26	x	x	x						x		x	Not Used		
				x	x	x	x	x				0.07	190-3747	SR
										x		0.2	190-3636	SR
R27	x	x	x									Not Used		
				x	x	x	x	x	x	x	x	220	280-1145P50	AB, EB
R28A	x	x	x									Not Used		

Table 6-1
Replacement Parts List (cont'd)

CIRCUIT SYMBOL	QSA Models 18-1.1	18-1.9	18-3.0	48-.4	48-.8	48-1.2	75-.5	75-.8	120-.5	175-.25	265-.15	DESCRIPTION	SORENSEN PART NUMBER	MANUFACTURER, TYPE
												Resistors (ohms, 1/2W unless noted - cont'd)		
(cont'd)														
R28A				x	x	x						22K, 1W	280-1180P122	AB, HB
							x	x				47K, 1W	280-1180P134	AB, GB
									x			68K, 2W	280-1147P140	AB, HB
										x		100K, 2W	280-1147P146	AB, HB
											x	47K, 2W	280-1147P133	AB, HB
R28B	x	x	x	x	x	x	x	x	x	x		Not Used		
											x	47K, 2W	280-1147P133	AB, HB
R29	x	x	x	x	x	x	x	x				Not Used		
									x			10K, 2W	280-1147P109	AB, HB
										x		27K, 2W	280-1147P124	AB, HB
											x	47K, 7W	280-1147P133	AB, HB
R30	x	x	x	x	x	x	x	x				Not Used		
									x			10K, 2W	280-1147P109	AB, HB
										x		27K, 2W	280-1147P124	AB, HB
											x	47K, 7W	280-1147P133	AB, HB
T1	x											Transformer	126-2883	SR
		x										"	126-2884	SR
			x									"	126-2885	SR
				x								"	126-2974	SR
					x							"	126-2973	SR
						x						"	126-2969	SR
							x					"	126-2972	SR
								x				"	126-2970	SR
									x			"	126-2971	SR
										x		"	126-3063	SR
											x	"	126-3064	SR
TB1	x	x	x	x	x	x	x	x	x	x	x	Terminal Strip	43-082-2	
												Miscellaneous		
	x			x								Cover, End	73-1596	SR
		x			x		x						73-2177-2	SR
			x			x		x	x				73-2177-4	SR
										x	x		73-2742	SR
	x	x		x	x		x					Cover, Side	73-1595	SR
			x			x		x	x	x	x		73-1648	SR
	x			x									73-1597	SR
		x			x		x						73-1632	SR
			x			x		x	x	x	x		73-1649	SR
	x	x		x	x		x					Chassis	73-1598	SR
			x			x		x					73-1650	SR
									x				90-3663	SR
										x	x		73-2741	SR
	x											PCB Ass'y	190-3615-4	SR
		x											190-3615-5	SR
			x										190-3615-6	SR
				x									190-3748-1	SR
					x								190-3748-2	SR
						x							190-3748-3	SR

Table 6-1
Replacement Parts List (cont'd)

CIRCUIT SYMBOL	QSA Models												DESCRIPTION	SORENSEN PART NUMBER	MANUFACTURER, TYPE
	18-1.1	18-1.9	18-3.0	48-.4	48-.8	48-1.2	75-.5	75-.8	120-.5	175-.25	265-.15				
													Miscellaneous (cont'd)		
						x							PCB Ass'y	190-3748-4	SR
							x							190-3748-5	SR
								x						190-3748-6	SR
									x					190-3937-1	SR
											x			190-3937-2	SR

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